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Optomagnetic (OM) sensing relies on measurements of the intensity modulation of light of wavelength λ transmitted through a magnetic nanoparticle (MNP) dispersion in response to an oscillating magnetic field, $B(t) = B_0 \sin(2\pi f t)$.[1] Upon application of a magnetic field single-core or multi-core MNPs with linked optical and magnetic anisotropies will change their orientation resulting in a change of the intensity of transmitted light (**Fig. 1a**). The degree of field-induced alignment is determined by the magnitude but not the sign of the applied field and therefore the effect of the particles is observed in the even harmonics of the applied magnetic field. OM measurements can be performed as function of f and/or B_0 and can be realized in a fairly simple setup, which is suited to be used as readout in a low-cost disposable lab-on-a-chip system as the technique requires only a transparent sample container. Although OM measurements may seem restricted to particular nanoparticle systems, we have found that surprisingly many commercially available particle systems show a significant OM signal and hence can be studied and used by this technique.

Measurements typically measure the synchronous 2nd harmonic OM response vs. the frequency f of the magnetic field applied at low amplitude (**Fig. 1b**). Such measurements can be used to infer the distribution of hydrodynamic diameters, D_h, of the MNPs and are thus sensitive to changes of D_h resulting from binding or growth of biomolecules to individual MNPs or to clustering of MNPs.[2] MNP clusters with dimensions comparable to λ interact differently with the light and often show an OM response of opposite sign to that of individual MNPs.[1] This makes OM measurements very sensitive to the formation of MNP clusters. Moreover, measurements vs. f and B_0 can be used to estimate the distributions of D_h and remanent magnetic moments as well as their correlation.[3] Thus, OM measurements are suited for determination of MNP properties and for verification of the colloidal stability of MNP dispersions.

In our group we have moreover developed the OM technique to a powerful tool for real-time studies of nucleic acid detection and amplification. These studies have mainly used BNF 100 nm multicore particles from Micromod and relied on setups with integrated temperature control capable of measuring a single frequency spectrum in 40 s or less. As examples, we have studied in real-time: (1) the target-induced clustering of MNPs,[4] (2) the growth of amplification products,[5] and (3) DNA hybridization and denaturing under changing conditions.[6] In this presentation, we will introduce the technique and give an overview on how we have applied it for sensing and various types of DNA-based biosensing.

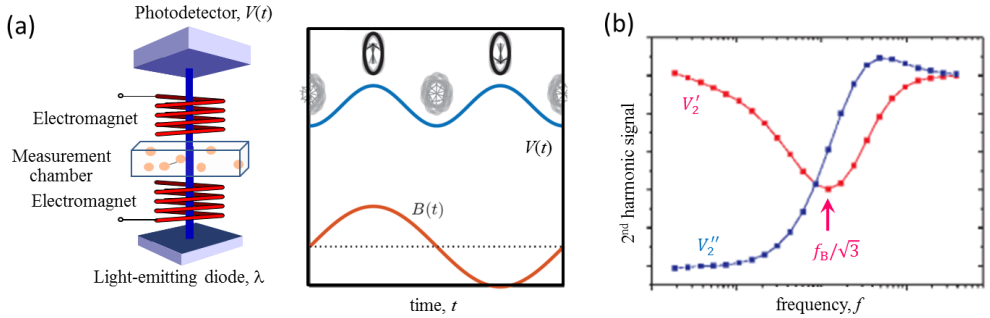

Figure 1 (a) Principle of OM measurements. (b) Example of OM spectrum. The in-phase $\sin(4\pi f t)$ component, V_2', shows a peak at $f_B/\sqrt{3}$, where $f_B = k_B T/(\pi^2 \eta D_h^3)$ is Brownian relaxation frequency (η is the viscosity).

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[3] J. Fock *et al.*, Nanoscale **10**, 2052–2066 (2018).
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[5] G.A.S. Minero *et al.*, Analyst **142**, 3441-3450 (2017).
[6] G.A.S. Minero *et al.*, Analyst **142**, 582-585 (2017).